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# Stochastic approach for faculty turnover in higher education institutions using Erlang truncated exponential distribution

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**Abstract**

Various studies have been undertaken on applying stochastic modeling in organizations with varying academic ranks of their employees. However, no studies have been conducted on faculty turnover in higher education institutions using Erlang Truncated Exponential distribution. The research aimed to evaluate the Distribution fit for faculty turnover within a higher education institution. The simulation work determined parameter values for this distribution. The research findings showed faculty members with higher academic ranks tend to stay longer at their positions. Hence, the policymakers of HEIs should frame suitable strategies to enhance the length of stay of faculty members, thereby boosting the quality of higher education.

***Subject Classification:*** *93E20, 68T05.*

***Keywords:*** *Academic rank, Erlang truncated exponential distribution, Faculty members, Goodness of fit, Higher education institution, Model.*

## 1. Introduction

As personnel are critical for optimal performance, employee turnover is a significant concern for organizations [1]. Attracting and sustaining employees is treated as an intelligent strategy for sustaining organizational performance and holding a place in the competitive market. Turnover intention among employees is a critical issue in all kinds of organizations, including higher education institutions (HEIs), where academic staff members are prone to leaving their positions [7]. Moreover, a high rate of employee turnover may reduce customer satisfaction, increase costs, and lead to a decline in organizational productivity [1]. Concerning the higher educational context, faculty turnover can disrupt the teaching environment, and it can cause a strain on the institution's resources. It can also have a severe impact either directly or indirectly on both the institution and the students [15].

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Additionally, the turnover behavior among faculty members might lead to a decline in both the number and quality existing in HEIs [9]. The direct costs for the recruiting process by the human resource department of HEIs are observed as high despite poor returns. The issue of faculty departure is denominated "Brain Drain" as the caliber of HEIs is contingent upon a highly competent workforce [15]. In addition, rising instances of academic personnel transition are recognized as an indication of educational system shortcomings that would affect student achievement resulting in reduced instructional quality [9], [12]. The principal factors that shape faculty turnover in the higher education sector include gender, job position, job stress, workload, interpersonal relationships, job satisfaction, working conditions, organizational commitment, and pay [1], [11], [15] have recommended adopting the strategy of influencing the employees who intend to leave, and when they do, instead of reducing the overall employee turnover requirements. In this regard, various statistical approaches have been applied to predict the exit time of staff at different levels in an Institution [2], [10], have created a model that uses a three-parameter generalized exponential distribution to calculate the time for hiring in an organization's grading system. It is inferred that a rise in the inter-arrival time causes a decrease in the time that takes to attract new personnel. Al Kuwaiti et al., [2], indicated that lengthening intervals between arrival points correlate with extended projected employment duration before voluntary departure occurs. It is concluded that the Additive Weibull statistical framework presents a viable methodological approach for forecasting personnel separation timelines within organizational contexts.

Moreover, in an academic labor market, faculty members' turnover has turned into a critical phenomenon in human resources, and there is a need for early detection and monitoring of faculty members' turnover as it leads to positive and negative consequences [3]. Consequently, the present investigation aimed to estimate the goodness of fit through Erlang Truncated Exponential Distribution in different academic ranks of an HEI. El-Alosey [5] proposed the "Erlang-Truncated Exponential (ETE) distribution", which is an expansion of the ordinary one-parameter exponential distribution and is widely used in reliability engineering as well as other areas. The ETE distribution is the outcome of combining the "Erlang" and "Left truncated" one-parameter exponential distributions.

The manuscript is structured methodologically as follows. Section 2 develops a theoretical framework centered on deriving the pdf of the ETE distribution to formalize its analytical properties. Section 3 employs

computational simulations and analytical techniques to model projected tenure durations among academic faculty. Section 4 synthesizes empirical results and conclusion.

## 2. Methodology

*Model Building*

Several distributions have been fitted into the stochastic model using the shock model to evaluate an organization's grading system [10], [13], [14]. However, this study focused on the intentions of university teachers to leave their jobs. Concerning this objective, the first assumption is made as the faculty member intends to leave the HEI due to the lack of job advancement, i.e., lack of promotion from low academic rank to high academic rank. The second assumption defined that the HEI is not recruiting new faculty members to any academic ranks.

Using a renewal model for an organization, a recent study demonstrated the renewal time of an employee in a specific grade [16]. Here, this study calculates K academic ranks in time; HEI counts faculty members with no waiting time as zero. The total faculty members at a specific academic rank recorded, together with the group size and length of stay. The following renewal process equation is

$$V_k(t) = F_k(t) - F_{K+1}(t)$$

The following equation (1) is used to assess how long faculty members of a specific academic rank will survive without causing harm to the HEI.

$$S(t) = \sum_{k=0}^{\infty} V_k(t) P(X_i < Y) \tag{1}$$

The items observed in the academic ranks of the HEI are $K$ academic ranks and time. This investigation anticipates the statistical distribution Y as the primary input element, specifically of continuous nature. The quantity of instructional staff '$i$' within a designated academic classification is determined as $X_i$. Advancement likelihood for faculty transitioning from entry-level positions (Assistant Professor) to senior classifications (Professor) is represented as $P(X_i < Y)$. Departures are categorized as resource diminishment when instructional personnel exit their current academic classification at any temporal point (t).

Additionally, the present research develops the pdf of $Y$ for recruitment processes as in equation (1).

$$(f(x) = \theta(1-e^{-\lambda})e^{-\theta x(1-e^{-\lambda})} \qquad x \geq 0, \quad \theta, \lambda > 0, \tag{2}$$

where $\theta$ is the shape parameter and $\lambda$ is the scale parameter.

As shown in this model, the convolution theorem of the probability density function of Y was used to generate a simplified equation.

$$h(u) = e^{-\theta x(1-e^{-\lambda})} \tag{3}$$

The Laplace conversion of formula (2) is mathematically derived and subsequently presented in next equation:

$$L(T) = \frac{[1-g^*(\theta-\theta e^{-\lambda})]f^*(s)}{[1-g^*(\theta-\theta e^{-\lambda})f^*(s)]} \tag{4}$$

When the faculty members arrive, the temporal interval for advancement from subordinate positions to elevated classifications commences measurement at this point. The population of academic personnel and the temporal duration between progressions within each classification is represented by parameter 'c' within the exponential distribution. When the exponential parameter 'c' is replaced in equation (5), as $f^*(s) = \left(\frac{c}{c+s}\right)$, this study derives the expected time of faculty members in a specific academic rank of HEI.

Each academic rank in the HEI is a queue with sufficient faculty members. The statistical distribution follows the faculty member's queue in every rank of HEI. The number of faculty members is a random variable with parameters $(\theta, \lambda, \mu, c)$ and is independent and identically distributed. The subsequent equation represents the faculty members' expected length of stay.

$$E(t) = \frac{(\mu+\theta)(\mu+\theta e^{-\lambda})}{c[\mu^2+2\theta\mu+\theta^2 e^{-\lambda}]} \tag{5}$$

## 3. Simulation

For this model in an HEI, the simulation approach was used, and academic ranks were classified as Academic rank I-Assistant Professor, Academic rank II-Associate Professor, and Academic rank III-Professor. The simulation from equation (5) was analysed with Mathcad software, and the length of stay of the faculty member in an HEI was calculated. The stochastic approach was used in these different scenarios to optimize strategies aimed at reducing faculty turnover.

**4. Results**

From Table 1, it is inferred that if HEI does not do the job promotion, then the expected length of stay among Assistant Professors (Academic rank I), Associate Professors (Academic rank II), and Professors (Academic rank III) is observed as high at a specific year (i.e., Year 1). However, it will decline in the consecutive years till Year 10. The expected length of stay of faculty members with different ranks is observed to increase in ascending order, i.e., Assistant Professors followed by Associate Professors and Professors if the HEI failed to do job promotion. Moreover, the expected length of stay is found to be high among Professors than Associate Professors and Assistant Professors.

Secondly, the assumption is made as HEI does not do the new recruitment. In this case, Table 1 demonstrated that the expected length of stay among Assistant Professors (Academic rank I), Associate Professors (Academic rank II), and Professors (Academic rank III) is observed as high at a specific year (i.e., Year 1). Whereas it will decline in the consecutive years till Year 10. It is observed that the expected length of stay of faculty members with different ranks increases in ascending order from Assistant Professors, followed by Associate Professors and Professors if HEI does not do the new recruitment. Furthermore, the expected length of stay is found to be high among Professors than Associate Professors and Assistant Professors.

In both the assumptions, the expected length of stay is found to be high among Professors in HEI. It might be due to the promotion of Professors to the next level (i.e., Dean or Vice Dean) will take some years to occur. Retirement or death could also be the reason for someone leaving an HEI. These findings are consistent with prior studies that used various statistical distributions [2], [4], [6], [8]. HEIs also focus on Professors to maintain an adequate number of highly experienced faculty. On the other hand, the expected length of stay among Assistant Professors is found to be low under these two assumptions. This reduced expected length of stay of Assistant Professors in HEI might be due to the heavy workload resulting from no new recruitment and lack of job promotion in their career. It is inferred that the Assistant Professors would move to a new job with a higher academic rank if their current HEI does not promote them. Also, this shift among Assistant Professors may relieve them from the increased workload due to the lack of new recruitment in their current HEI.

**Table 1**

**Percentage of responses in the questionnaire**

| *c* | Academic rank I | | Academic rank II | | Academic rank III | |
|---|---|---|---|---|---|---|
| | R | P | R | P | R | P |
| Year 1 | 5.44 | 2.347 | 3.45 | 2.307 | 2.275 | 1.496 |
| Year 2 | 2.72 | 1.173 | 1.725 | 1.154 | 1.138 | 0.748 |
| Year 3 | 1.813 | 0.782 | 1.15 | 0.769 | 0.758 | 0.499 |
| Year 4 | 1.36 | 0.587 | 0.862 | 0.577 | 0.569 | 0.374 |
| Year 5 | 1.088 | 0.469 | 0.69 | 0.461 | 0.455 | 0.299 |
| Year 6 | 0.907 | 0.391 | 0.575 | 0.385 | 0.379 | 0.249 |
| Year 7 | 0.777 | 0.335 | 0.493 | 0.33 | 0.325 | 0.214 |
| Year 8 | 0.68 | 0.293 | 0.431 | 0.288 | 0.284 | 0.187 |
| Year 9 | 0.604 | 0.261 | 0.383 | 0.256 | 0.253 | 0.166 |
| Year 10 | 0.544 | 0.235 | 0.345 | 0.231 | 0.228 | 0.15 |

*Note:* R-Recruitment, P-Promotion, Academic Rank I-Assistant Professor, Academic Rank II-Associate Professor, Academic Rank III-Professor

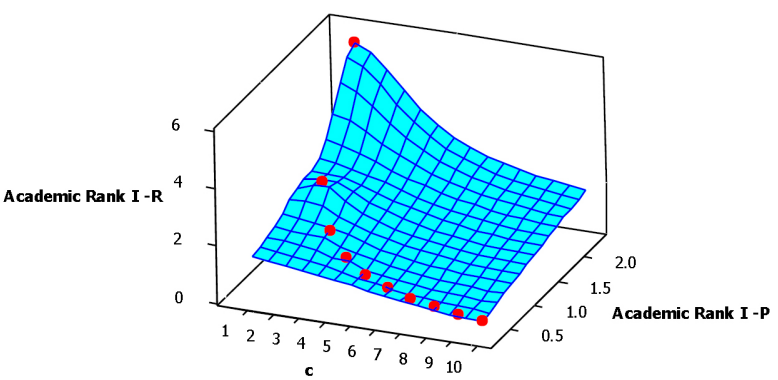



**Figure 1**

**Relationship between Academic rank I with Recruitment and Promotion**

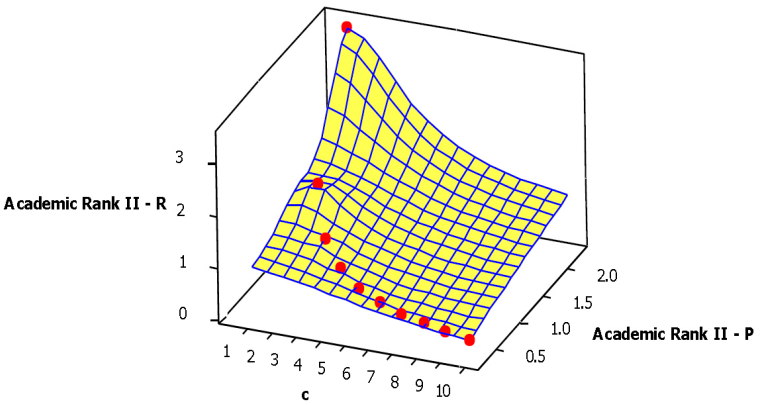



**Figure 2**

**Relationship between Academic rank II with Recruitment and Promotion**

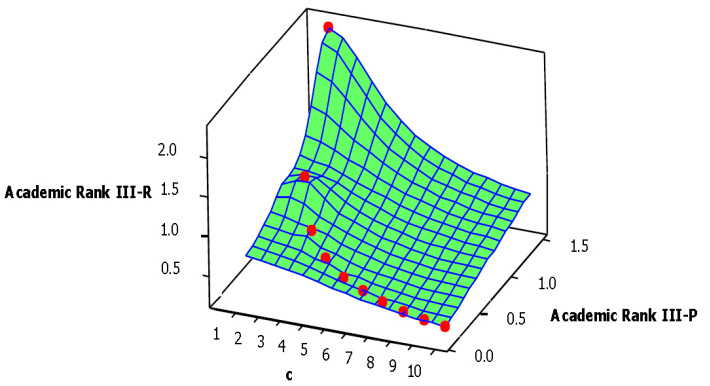



**Figure 3**

**Relationship between Academic rank III with Recruitment and Promotion**

The Figure 1-3 illustrate the relationship between academic rank (I, II, and III) and the variables of recruitment and promotion, showing a decreasing trend in promotion opportunities as academic rank increases.

Therefore, HEI administrators should focus on job promotion and new recruitment at different academic ranks with appropriate strategies to facilitate the length of stay of faculty members. Such an attempt would improve the quality of higher education, thereby enhancing the students' satisfaction. It would aid HEIs in sustaining their position in the competitive higher education market.

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